# AUXILIARY JIG

## BACKGROUND OF THE INVENTION

The present invention relates to an auxiliary jig used for forming a structure made of a fiber-reinforced composite.

Stiffened panels made of a fiber-reinforced composite (prepreg) are light in weight and high in strength to have been widely used for automobiles, ships, aircrafts, etc. The stiffened panels generally comprise a skin strengthened by a plurality of stiffeners (stringers and frames), the skin and the stiffeners being integrally formed. Fig. 1 is a partial perspective view showing an example of the stiffened panel. A stiffened panel *1* shown in Fig. 1 comprises a skin *2* and a stiffener *3* integrally formed therewith. As shown in Figs. 4(a) and 4(b), the stiffened panel may be produced by a method comprising the steps of: placing a skin member *2* and a preformed stiffener member *31* each made of a fiber-reinforced composite on a forming tool *4*; disposing a couple of jigs *5a* and *5b* on the preformed stiffener member *31*; and integrally forming the skin member *2* and the preformed stiffener member *31* by heating under a pressure using a pressure bag, etc.

The above-mentioned method is disadvantageous in that a resin contained in the fiber-reinforced composite often flows out from an interspace between the jigs *5a* and *5b* in the direction of arrow *A* shown in Fig. 4(b) while heating under a pressure. If a large quantity of the resin flows out from the interspace, the resultant fiber-reinforced composite structure is poor in such a quality as strength, rigidity, etc. Thus, as shown in Fig. 5, the resin has been conventionally restrained from flowing out by sticking a temperature resistant tape *7* to the preformed stiffener member *31* and the jigs *5a* and *5b* disposed thereon. However, the process of sticking the temperature resistant tape is complicated and troublesome, thereby requiring much effort.

Further, in the above-mentioned method, the jigs *5a* and *5b* often fall

down while heating under a pressure as shown in Fig. 6. In this case, the resultant fiber-reinforced composite structure is poor in form accuracy with unevenness stiffener thickness. The fiber-reinforced composite structure can be formed with high form accuracy by using a large-scale jig together with the jigs *5a* and *5b*, however, this results in increased costs and poor workability.

OBJECT AND SUMMARY OF THE INVENTION

An object of the present invention is to provide an auxiliary jig used for forming a structure made of a fiber-reinforced composite with high form accuracy without reduction of strength and rigidity.

As a result of intensive research in view of the above object, the inventors have found that a structure made of a fiber-reinforced composite having desired strength and rigidity can be formed with high form accuracy by using a particular auxiliary jig together with a couple of jigs while forming. The present invention has been accomplished by the finding.

Thus, an auxiliary jig of the present invention is used with a couple of jigs for forming a structure made of a fiber-reinforced composite by heating under a pressure, the auxiliary jig being provided between the couple of jigs to prevent the jigs from falling down and to restrain a resin contained in the fiber-reinforced composite from flowing out from an interspace between the jigs.

The auxiliary jig of the present invention preferably comprises a rigid portion and an elastic portion. The rigid portion is preferably made of a stainless steel, aluminum, graphite or CFRP, and the elastic portion is particularly preferably made of a silicone rubber.

The auxiliary jig of the present invention is particularly preferably used for forming a stiffened panel. Thus, a stiffened panel having uniform, excellent qualities can be produced with high form accuracy by a method comprising the steps of: placing an skin member and a preformed stiffener member each made of a fiber-reinforced composite on a forming tool; disposing

the couple of jigs on the preformed stiffener member; providing the auxiliary jig of the present invention between the jigs; and integrally forming the skin member and the preformed stiffener member by heating under a pressure.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a partial perspective view showing an example of a stiffened panel;

Fig. 2 is a partial sectional view showing formation of a stiffened panel, where an auxiliary jig of the present invention is used;

Figs. 3(a) and 3(b) are a sectional view showing an example of an auxiliary jig of the present invention, respectively;

Fig. 4(a) is a partial perspective view showing formation of a stiffened panel by a conventional method;

Fig. 4(b) is a partial sectional view showing formation of a stiffened panel of Fig. 4(a);

Fig. 5 is a partial sectional view showing formation of a stiffened panel, where a temperature resistant tape is stuck to a preformed stiffener member and jigs; and

Fig. 6 is a partial sectional view showing formation of a stiffened panel, where jigs fall down while forming.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An auxiliary jig of the present invention is used with a couple of jigs when a structure made of a fiber-reinforced composite is formed by heating under a pressure. The auxiliary jig is provided between the jigs while heating the fiber-reinforced composite structure under a pressure to prevent the jigs from falling down and to restrain a resin contained in the fiber-reinforced composite from flowing out from an interspace between the jigs.

The auxiliary jig of the present invention may be used for forming

various fiber-reinforced composite structures, and it is particularly preferably used for forming a stiffened panel. Formation of a stiffened panel *1* shown in Fig. 1 using the auxiliary jig of the present invention will be explained in detail below without intention of restricting the scope of the present invention, with reference to drawings.

As shown in Fig. 2, the stiffened panel is produced by a method comprising the steps of: placing an skin member *2* and a preformed stiffener member *31* each made of a fiber-reinforced composite on a forming tool *4*; disposing the jigs *5a* and *5b* on the preformed stiffener member *31*; providing the auxiliary jig *6* according to the present invention between the jigs *5a* and *5b*; and integrally forming the skin member *2* and the preformed stiffener member *31* by heating under a pressure.

As shown in Fig. 2, side surfaces of the preformed stiffener member *31* are exposed to the outside. It is preferred that a sheet made of a silicone, etc. is disposed on each of the side surfaces to prevent a resin contained in the fiber-reinforced composite from flowing out from the side surfaces.

The couple of jigs used together with the auxiliary jig of the present invention may be made of a known material such as a steel, aluminum, etc. Further, the forming tool may be made of FRP, a steel, aluminum, etc.

The auxiliary jig of the present invention preferably comprises a rigid portion and an elastic portion. For example, the auxiliary jig *6* shown in Fig. 3(a) comprises a rigid portion *61* and an elastic portion *62*. As shown in Fig. 3(b), the rigid portion *61* may be covered with the elastic portion *62*. It is preferable that the rigid portion *61* and the elastic portion *62* are integrally formed by liquid injection molding.

The rigid portion *61* acts to prevent the jigs *5a* and *5b* from falling down, thereby controlling thickness of the preformed stiffener member *31*. Although shape of the rigid portion is not particularly limited, width *L* of the rigid portion *61* shown in Fig. 3(a) is preferably equal to the desired width of the fiber-

reinforced composite structure. The rigid portion is preferably made of a material that is excellent in dimensional stability, strength and rigidity, and low in thermal expansivity. Examples of such a material include: metals such as stainless steels and aluminum; graphite; CFRP; etc.

The elastic portion *62* acts to restrain the resin contained in the fiber-reinforced composite from flowing out from the interspace between the jigs *5a* and *5b*. The elastic portion is preferably made of an elastomer high in flexibility and thermal resistance, more preferably made of a silicone rubber or a teflon rubber. Of these, the silicone rubber is particularly preferable from the viewpoints of releasability and liquid injection moldability. If the entire auxiliary jig of the present invention is made of a rigid material such as aluminum, etc., there is a case where the resin contained in the fiber-reinforced composite flows out from interspaces between the jigs and the auxiliary jig. The elastic portion is pressed to the jigs by the forming pressure, whereby the interspaces between the jigs and the auxiliary jig is sufficiently sealed to more effectively restrain the resin from flowing out. Shape of the elastic portion is not particularly limited if only it can be stuck to the jigs.

The auxiliary jig of the present invention may be used for forming a structure made of a fiber-reinforced composite composed of such a reinforcing fiber as a carbon fiber, a glass fiber, an aramid fiber, etc. impregnated with a thermosetting resin or a thermoplastic resin. Examples of the thermosetting resin include epoxy resins, bismaleimide resins, phenol resins, etc., and examples of the thermoplastic resin include PEEK, nylon 6, nylon 66, polyethylene terephthalate, etc.

The auxiliary jig of the present invention may be used in the case where the fiber-reinforced composite structure is formed by long period of heating at a high temperature under a high pressure. For example, the auxiliary jig of the present invention can sufficiently prevent the fall down of the jigs and the flow out of the resin when the structure is formed by heating at 120 to 180 °C under a

pressure of 5 to 20 kg/cm$^2$ for 1 to 2 hour. The structure may be heated under a pressure by an autoclave, etc. The auxiliary jig of the present invention may be used repeatedly.

Though the auxiliary jig of the present invention has been explained above with reference to the attached drawings, the present invention is not restricted thereto and any variations and modifications are possible unless the scope and spirit of the present invention are changed.

As described in detail above, an auxiliary jig of the present invention used together with a couple of jigs acts to prevent the jigs from falling down and to restrain a resin from flowing out from an interspace between the jigs, whereby a fiber-reinforced composite structure is formed with excellent qualities and high form accuracy. The auxiliary jig of the present invention is particularly preferably used for forming a stiffened panel.